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ABSTRACT

This paper discusses preliminary results from an in-laboratory experiment to study enroute driver behavior under ATIS. The case study was conducted using FASTCARS (Freeway and Arterial Street Traffic Conflict Arousal and Resolution Simulator), an interactive microcomputer-based travel choice simulator. The experiment was designed to both exhibit the value of using computer simulation for data collection and to explore factors that influence and induce changes in enroute driver behavior. A range of statistical methods were applied on both a driver and an enroute event basis to investigate underlying relationships between driver behavior and the selection and utilization of real-time information technologies. Logit models were developed for both primary and secondary diversion behavior, incorporating variables that capture the utility choice associated with enroute decision processes. Utility assessment modeling was performed to examine the potential benefits of in-vehicle navigation systems. The analyses suggest that driver familiarity both with travel conditions and network layout strongly influences driver behavior and need to acquire information. The initial results indicate that although real-time information acquisition is generally useful for clarifying drivers' perceptions of travel conditions and assisting with route choice decisions, the value of information acquisition may decrease among more experienced drivers.

INTRODUCTION

Recently, several studies have been undertaken to study enroute behavior under the influence of real-time traveler information with in-laboratory experimentation (Bonsall and Parry, 1991; Allen et al., 1991; Ayland and Bright, 1991). There is general consensus that simulation is a powerful tool for emulating the driving process and eliciting responses that are similar to those expected under real-world conditions.

Enroute driver behavior has been categorized as an iterative process through which drivers assess the current state of the system and adapt travel behavior in response to the severity of perceived travel conditions (Adler et al., 1992a; Khattak et al, 1992; and Ben-Akiva et al., 1991). Changes to enroute behavior include route diversion, information acquisition, and revision of travel objectives.

Several key factors are known to influence enroute choice including, but not limited to, perception and knowledge of current path conditions (delay, expected travel time, congestion level), knowledge (or perception) of the existence of alternate routes and travel conditions on these routes, affinity toward taking risks, thresholds of tolerance to traffic conditions, and certainty of meeting travel goals or expectations. In addition to these variations across a population, driving behavior also varies for individuals based on trip characteristics such as trip type, time of day, and other considerations.

This paper describes in-laboratory experiments, performed with an interactive driver simulator, to study the impacts of real-time traveler information on enroute driver behavior. The case study extends the work described by Adler et al., (1992a, 1992b) in using conflict theory and in-laboratory interactive simulation to examine enroute driver behavior.

DESCRIPTION OF CASE STUDY

An interactive computer-based driving simulator, FASTCARS, was developed to test the hypotheses on conflict theory and to provide a platform for studying driver behavior under ATIS (Advanced Traveler Information Systems) technologies. FASTCARS simulates basic driver decisions (goal formulation and route choice) and emulates three ATIS technologies (variable message signs (VMS), highway advisory radio (HAR), and in-vehicle navigation systems (IVNS)). Players are evaluated by a linear weighted utility function. Five goals and utility functions are predetermined and players are allowed to specify their weighting scheme. This section briefly describes how FASTCARS was designed for the case study. For greater detail on the experiment and the simulator please refer to Adler et al., (1992a, 1992b).

The Hypothetical Network

Driver familiarity with network layout and traffic conditions is an important determinant of behavior. To study familiarity as a factor of diversion and information acquisition behavior it was necessary to create an artificial environment where familiarity could be controlled. Therefore, for the case study, a hypothetical travel network, the city of Terrapin, was constructed. Figure 1 depicts the hypothetical network. The Terrapin traffic network is a system of arterials, freeways, and a beltway that circles the inner city. Both the beltway and freeway have higher free mean speeds, the difference being that the beltway has four lanes in each direction while the Freeways only have three. Arterials are coded having two lanes in either direction.

The traffic network in Terrapin was well planned and as a result lies in an almost grid-like structure. Arterials and freeways are placed in a general order, almost consistent with the manner prescribed in the United States except the notation is opposite of the Interstate system. Odd numbered freeways in Terrapin run generally north-south with higher numbers to the West. East-west Freeways in Terrapin are even-numbered with higher numbers more Southerly. Surface streets are located in similar fashion. North-South arterials are denoted by numbered streets (i.e., 50'th St, 25'th St, etc.) with 50'th St. being Westmost. East-West arterials are denoted as avenues named after past Presidents (Terrapin being quite the All-American city) running from Washington Avenue in the North to Ford Avenue Southmost in the city.

Familiarity was recreated in the case study by creating three sets of maps that depict subsets of the entire network. These sets of maps, denoted Novice, Intermediate, and Expert, define a player's knowledge of the physical layout and characteristics of traffic conditions.

Players are allowed to look at these maps throughout the game without penalty. When the set of maps is accessed by players, the game pauses until the player is ready to continue. The first time a player uses FASTCARS, the program randomly selects a familiarity level. Thereafter, players can move to the next level of familiarity after completing several trials. The sets of maps were developed as follows:

Novice players are assumed to be drivers with little or not experience driving on the network. Their network was developed having only a few of the available freeways and stadium accesses drawn on it. Therefore they are provided with only two maps, the first detailing the network as displayed for them and the second displaying distances along freeway links. Players with more familiarity are assumed to have fairly good knowledge of the freeway system but limited experience on surface streets. In addition, from previous freeway travel intermediate drivers begin to have a sense of mean travel speeds. Intermediate drivers are therefore equipped with three maps: general network drawing, freeway distances, and freeway speed distributions. Expert drivers have much experience driving the freeways and arterials in the city. They are therefore given a more detailed set of maps. Experts are equipped with 5 maps containing information on general network layout, freeway distances, freeway speeds, probability of incident occurrence, and surface street speed distribution.

Player's Tasks

In FASTCARS, players have a series of tasks that they need to perform as part of the pre-trip planning and enroute driving processes. In the pre-trip planning stage, players are asked to select an initial route based on a set of maps provided to them. In addition, players must specify their travel objectives by assigning weights to a predefined utility function. Both of these acts are described in greater detail below.

While enroute, players have three actions that they can undertake: road changing, lane changing, and information acquisition. In FASTCARS players do not directly control their cars. Speeds are determined by lane and players can achieve faster speeds by switching to a lane with a higher speed. Players have total control over road changing and must navigate their cars through the network to the destination. Players can also actively seek real-time information through the Highway Advisory Radio and In-Vehicle Navigation Systems provided to them. The HAR system provides real-time traffic incident and congestion information for the freeways in the network. The IVNS calculates a shortest time path from the player's position to the destination. Players are informed of the calculated times and distance on this path and are advised as to the next road change on this path.

Modeling Incidents

The application was programmed to simulate both minor and major freeway incidents. From the incident probabilities assigned to each link coded in the link file, ten incident files were generated, and corresponding HAR files recorded. At the start of each simulation, FASTCARS randomly selects one of the ten incident files to use during the program. By having a large number of incident files, players will experience different levels of congestion and it will be more difficult for one person to influence anothers' perspective of the simulation. Furthermore, it is also possible to study longitudinal impacts of travel because over repeated trips, players will adapt their behavior based on their ability to recognize traffic patterns and identify incident probabilities.

Experiment Control

To control the variability in the simulation, several parameters were preset. All trials were performed with the identical origin-destination pair and all players had the same departure and desired arrival times. The set of five travel goals, associated normalizing functions, and penalty units for using ATIS technologies remained constant over all players. Variability among the players was captured by each player's user level of experience, specification of goal weights, initial route choice, and enroute decision processes.

To determine diversion points, FASTCARS was programmed to query the player at each road change to determine whether the road turn was a continuation of the current planned route or a diversion from the current route. At the end of the simulation, players are asked to identify their initial route choice.

Scoring

FASTCARS models travel performance and route selection through a multiobjective goal set. Each player is rated according to relative success in maximizing utility over a goal set consisting of five predetermined goals. The five goals that are considered are: (1) arrive at destination 20 minutes early, (2) minimize travel time, (3) minimize number of stop lights encountered, (4) minimize number of road changes, and (5) minimize trip distance.

Players are scored on their ability to meet the prescribed travel goals. At the end of the program, each goal is normalized to a score between 0 (worst) to 100 (best). To capture individual behavioral differences and preferences among players, each player is permitted to assign a set of subjective weights totaling 100 to the goal set, with at least 60 percent of the weight allocated to the first two goals. Using an additive utility model, the normalized scores are multiplied by their respective weights and added. Any accrued penalty units (discussed below) are deducted and the resultant total is the final score for the game. In total the maximum possible score a player can achieve is 10,000 points.

During the simulation, scoring is influenced by many factors. Under ideal-flow conditions it is expected that scores should range between 8500-9500 depending on the initial route selected, specified goal weights, and the manner by which players navigate the network. Should a player select a route having high congestion or incident, it is expected that performance will be reduced. Combinations of severe traffic congestion and "unlucky" route choice can lead to poor performance and scores below 5000.

It was expected that players selecting routes without severe congestion would receive higher scores, independent of their experience and user level. Expert and novice players selecting the same initial route and experiencing similar traffic conditions should be expected to receive similar scores. Rather it was expected that variations among players and scoring would be realized with respect to diversion behavior and acquisition of real-time information.

Penalty Deductions

To control for random use of ATIS technologies, players are assessed a small penalty for using HAR or IVNS. Radio penalty units are one-time lump sum levies assessed at the time the radio is turned on, 250 points for this case study. Penalty units for using the navigator are metered. A base penalty is incurred for turning the navigator on (200 points). Additional penalty units are accumulated per minute of usage (50 points per minute). Administering penalty units helps determine how useful information acquisition is to a player. The value of the penalty, the conditions under which the information is sought, and background data on player profiles are useful to estimate the impact of information on driver behavioral choice.

DATA SET

Twenty five people participated in the study. Each player participated in at least two and up to a maximum of ten trials; a total of 108 trials were collected. Players were recruited from around the university population and included students, professors, and administrative personnel. The initial session was conducted under guidance of an instructor who explained the workings of the simulator; successive trials were performed at players' convenience.

FASTCARS Output Event Files

Every FASTCARS trial produced an output event file listing each system event. System events were defined as road changes which included **left turn, right turn**, and **ahead;** and information events, recorded when players looked at the maps, turned on the radio, or initiated the in-vehicle navigator. These records also included system specific data to capture the trip status at the time of the event. The record line incorporates twenty variables including event type, diversion indicator, from-node and to-node labels, values of five travel objectives, current travel speed at event, indicators for VMS, HAR, IVNS, values of player's goal weights, and penalty units accrued. An example subset of event records is shown in Table 1.

The event file also records trial specific data and player specific data. Trial data include date of trial and input files used in the trip. Player variables include answers to behavioral questions and post-simulation questions. The first time a player participated in the study a series of 10 questions, designed to capture demographic information as well as a behavior/personality profile, were posed (See Adler et al., 1992b for a full discussion).

To perform various data analysis techniques, it was necessary to connect the player profile information with the trial event data. This was performed through the FASTCARS' data post-processor program. Two categories of files were newly created by this program, trial summary and event summary files. Figure 2 depicts the post-processing data flow. Table 2 lists the set variables and their definition.

Trial Summary File

The first output file generated by the post-processor is the 'trial summary'. This file contained a single record from each trial that summarized that trial's data, including player profile, in 30 variables. These variables include: Number of diversions in trial, player's level of experience, number of trials played by player, indicator of incidents generated during trial, player's gender and driving experience, responses to eight behavioral questions, initial route selected, total trip time and distance, schedule delay remaining at end of trip, number of road changes and stoplights encountered, average speed during trip, indicators for using VMS, HAR, IVNS, player's goal weights, penalty units accrued.

Event Summary Files

Event summary files contained event records gathered from all trials. The records were then sorted to create several data files which were used for varied data analyses. These files contained 67 record variables, 30 described as in the trial summary and an additional 37 variables calculated. These added variables included: average speed on current link, average speed on current path, average speed on current road, distance traveled on current path and current road, type of road coming from and turning to (freeway or arterial), experience map level of links coming from and turning to, number of previous times links have been traveled, speed gradient (change in speed between links), and ratio of current average link speed to expected link speed. Additionally, at each event, the output program calculated the best utility path to the destination and recorded the values for the current path and the best alternative path. The actual score and normalized score for each of the five goals was calculated (20 variables) as was the projected current path score and the projected best alternative path score. For the best alternative path, the map level and previous times traversed was also calculated.

TRIAL LEVEL ANALYSES

Descriptive Statistics

The case study data set consisted of 108 trials performed by 27 participants. To summarize the data set, frequency tables were calculated on the trial level data. The results of these analyses are illustrated in Table 3.

Upon playing FASTCARS for the first time, players were assigned a userlevel. After playing 4 trials, players are bumped to the next userlevel. In the 108 trials collected the distribution among the three userlevel categories was divided as follows: **level 1-novice** (40 trials - 37.0 percent), **level 2-intermediate** (42 - 38.9 percent), and **level 3-expert** (26 - 24.1 percent). During each trial, players the number of diversions was collected. In 62 trials players diverted at least once; the remaining 46 trials had no diversions.

Table 4 lists the frequency of initial route choice. Although the beltway has a projected longer distance, 49 percent of the players chose this route initially, with 39 Percent choosing the counterclockwise route. It is interesting to note that so many players selected routes that are less direct. Many players stated that although the beltway was less direct, they figures the speeds would be higher and there would be less chance of incident.

Although not shown here in a table, tabulations were performed to investigate initial route choice by user level. For novice players, in 16 of the 40 trips (40 percent), players selected the beltway as their initial route choice. This number increased to 64 percent of all intermediate players. Among expert players the number dropped to 38 percent. There was a trend where novice players who encountered incidents or heavy congestion on inner routes moved toward less direct routes. More experienced drivers tended to revert back to inner routes and used more surface street travel in trying to improve travel times. It was found that while beltway travel was marginally faster, congestion or incidents on the beltway left players often with fewer alternative choices.

Table 5 lists mean and standard deviations for several variables in the trial data set.. The average score for the data set is 7242.45 with a fairly large deviation of 2633.97. The game was set up so that players had a one hour window in which to make it to the game on time. The departure time was stated at 6:30 and the desired arrival time was 7:30. The average trip time of 2833.07 seconds, or roughly 47 minutes, suggested that most players were not only able to get to the stadium within the hour, but came close to meeting the first goal of arriving 15 minutes early.

It is interesting that the average trip distance was 29.16, well above the minimum distance 23.00. This is consistent with the previous table that indicated a players willingness to select the beltway as a primary route rather than shorter, more direct paths.

Category Models

Crosstabulations are useful to determine if two variables are related. For the trial and event data collected from the case study, a series of crosstabulations was performed to measure the strength of association between variables. Associated with each table to be presented are several statistics that measure the extent of association between the data. Of main concern is whether or not the two variables being compared are dependent or independent of each other.

Table 6 illustrates the strength of association between userlevel (familiarity with the network) and propensity to divert. It is shown that players with more experience were less likely to divert. A total of 21 of 26 expert trials had either no or a single diversion. Alternatively, among novices, almost 50 percent of the trials had at least two diversions.

These results may be explained by the tendencies seen in first time players of FASTCARS. Novice players in the case study were more likely to divert at the sign of low-level congestion. As a result they often diverted several times during a trip. As players became more experienced playing FASTCARS, they gained experience that enabled them to select more efficient initial and diversion routes, thereby minimizing the need for subsequent alternations in travel.

Table 7, comparing userlevel by ATIS information acquisition, illustrates that the use of har and ivns among players varied by their assigned user level. It is tabulated that players with higher userlevel are less likely to acquire additional information. Only 10.5 percent of all players using HAR were "expert" and of the expert trips, only 4 of 26 used HAR. Similarly, 10.5 percent of all players using IVNS were expert players and only 2 of 26 experts used the in-vehicle navigator.

These results seem to confirm the hypotheses of acquiring information to assess the severity of conflict and to help drivers decide whether or not to adjust their behavior en-route. "Expert" players generally have less need to acquire information. They are more familiar with traffic patterns and can better assess delays and congestion. In addition, their knowledge of alternate paths is also greater and thereby reduces the need to rely upon HAR and IVNS.

Table 8 presents a crosstabulation for player score by userlevel. This table shows that scores tended to improve the more experienced a player was. Among novice players 52 percent scored over 7500 but only 10 percent scored over 9000. Among "middle level" players 62 percent scored over 7500. This rose to 73 percent among expert players. On the other extreme, 33 percent of all novices scored below 5000.

This fell to 15 percent among intermediate players and only one expert player failed to score at least 5000.

Again these results are consistent with what one might surmise about driver behavior. More experienced drivers select more efficient initial travel paths and objectives that they are more likely to meet. Less experienced drivers are more likely to select inferior paths and may also specify travel objectives that are less easy to meet.

To examine the impact of information acquisition on the player's score, Table 9 lists a set of crosstabulations of player score by ATIS information acquisition. There is a strong relationship between HAR and score, indicating that players experiencing congestion and receiving lower scores were more likely to use HAR. Over 50 percent (22/42) of players with scores below 5000 used HAR during the trial. There was less association between score and IVNS. Generally, players were aided by using HAR and IVNS; over 65 percent of HAR users and over 68 percent of IVNS users scored over 5000.

These results indicate a tendency of players to acquire information under conflict arousal. Players who were facing uncertainty of travel conditions or choice of diversion paths opted to gather more information. As a result, those who acquired information were able to receive a respectable score.

Table 10 analyzes the cross effects of VMS, HAR, and IVNS. The result indicate that VMS is a "trigger" to gaining additional information. Over 30 percent of players receiving VMS messages of at least degree 2 turned on HAR. Over 80 percent of all players used HAR during a trial. A total of 15 of 19 players using IVNS did so under conditions in which VMS displayed messages of at least degree 2. It is striking that while IVNS was only used in 19 out of the 108 trials, HAR was used in all of these trials as well.

EVENT LEVEL CHOICE MODELING

The event level data was used to estimate two binary choice models of diversion behavior: primary and secondary diversions. In both cases diversion was treated as a binary variable, 0=NoDivert and 1=Divert. This section describes the modeling process.

Primary Diversions

The primary diversion event summary file was used to develop the binary choice model for enroute diversions. The primary diversion file included all turning movements prior to and including the first diversion record taken from the 108 event files. Trials with no diversions were included in this collection. This file contained nearly 1300 pre-diversion turning records.

Out of the 108 event files, 62 trials had at least one diversion. To formulate the data set for the analysis , the non diversion records were randomly sampled to create a reduced sample data set of approximately the same number of diversions and non-diversions. The result of the logit model estimation is shown in Table 11.

Six variables were found to be significant: **Aslink**, average link speed, has a negative coefficient indicating a decrease in speed leads to diversion. **Vms** has a positive value indicating the presence of a message sign forewarning of congestion also induces diversion behavior. Four link specific inputs are also significant. **Mtl** and **ontl**, reflecting driver's experience with the current path, are both negative. This indicates that drivers with less familiarity on the current route are more likely to divert. A positive coefficient on **matl**, indicates that better knowledge of the alternate path leads to increased diversion. **Typeatl** has a negative value to imply players preferred diversion to a freeway rather to arterials.

The value of rho-squared, an informal goodness-of-fit index for logit analyses denoted by 1-((convergence log likelihood) / (initial log likelihood), is 0.6217, which is indicative of a relatively good model fit.

Secondary Diversions

It was hypothesized that once diversion has occurred, resulting behavior, including secondary diversions, would be influenced by different factors. A second set of logit models was calculated using the secondary diversion file. The data variables for this set was identical to those from the primary diversion file. These records included all events that took place after primary diversion points. In this file there were 1000 total records, 84 of which were secondary diversions. Records were randomly sampled to create a data set of roughly equal proportion of diversions to non-diversions. The result of this logit model estimation is shown in Table 12.

Similar results to the primary diversion model were found with some notable exceptions. **Numdiver** (number of diversions in the trial up to this event) became significant. The more a player diverts, the more likely one is to divert again. Having additional information was not significant for secondary routing. One explanation is that diversions take drivers to surface streets where VMS and HAR are less useful. Additionally, for this model, **enddist** has a positive sign. This suggests that players are more likely to have several diversions further away from the destination. **Typetl**, entered this model indicating players were more likely to have several diversion from freeway links. This should be expected since a majority of travel in all trials was on freeway links.

Spdratio is significant in this model rather than average speed. After a first diversion, players are less likely to divert again when speed decreases. It is hypothesized that conflict thresholds vary by link and it is possible that after a first diversion, drivers become less sensitive with respect to absolute speed and more concerned about speed as it related to expected conditions.

POTENTIAL VALUE OF IN-VEHICLE NAVIGATION

To study the potential benefits of in-vehicle navigation, a set of analyses were performed to examine potential changes in player score if each player had in fact used the IVNS for the entire trip. For each trip, the link file and incident files loaded to the simulator are known. For each incident file (ten overall), a trial was conducted in which the IVNS was turned on at the start and remained on during the entire trial. The routing instructions suggested by the IVNS were followed and a set of values for the five goals was calculated.

For each trial played, the player's goal weights were matched to the corresponding incident file to calculate a projected score that the player would have received had the IVNS been used for the entire trip. This new total score represents the marginal value of IVNS. To measure the costs associated with using IVNS, various penalty units for initially turning on the IVNS and a per minute metered penalty were assessed. The first predicted improvement was tabulated assuming a cost for using IVNS: 200 points for turning on the IVNS and 25 points for each minute the IVNS was running. The second set of improvements was calculated assuming no penalties. These values were compared to the actual player scores. The results are shown in Figure 3 which graphs the observed average scored and the predicted average improvement in score for two levels of penalty assessments.

To relate IVNS usage to driver familiarity, the analysis distinguished among six classifications of drivers. The first, **ALL**, is for all players who participated in the case study. The second and third columns, **IVNS** and **HAR**, were those players who used either IVNS or HAR during their trip. The latter three categories are by userlevel (1=novice, 2=intermediate, and 3=expert) assigned to the players during the case study.

Figure 3 illustrates that under either IVNS scenario (base cost or no cost) there is a marginal improvement in scores. However, the degree of change varies among driver categories. With respect to driver familiarity, the results show that players with lower userlevels are predicted to have greater marginal improvements. Information acquisition would seem to offset inexperience and help less familiar drivers select more efficient routes. Alternatively, "expert" players would benefit less from the additional information.

DISCUSSION

This paper presented some initial data analyses from an on-going project to analyze enroute driver behavioral choice under ATIS with in-laboratory simulation. The FASTCARS simulator proved to be a valuable tool for performing interactive experiments, highlighted by its ability to simulate driving decision processes, emulate ATIS, and collect data.

Experience and familiarity with network conditions were found to be significant variables that impacted player performance and enroute decisions such as diversion and real-time information acquisition. It was observed that players with more experience had three advantages over less experienced players. First, experienced players generally selected more efficient initial routes. Second, experienced players were better able to develop travel objectives and weighting schemes that they could meet. Last, when faced with congestion, experienced drivers made better enroute decisions of diversion or staying on their current path.

It was hypothesized (Adler et al., 1991a) that perceived conflict and motivation vary temporally and by road being traversed. The models developed from the data collected in the case study illustrate that there are differences in driver behavior with respect to primary and secondary diversion. Further research is needed to better quantify these differences.

A significant result of these analyses was the limited impact of ATIS on driver behavior. Throughout the study, few drivers actually made use of HAR or IVNS. In the game, drivers were penalized for using these systems. From discussions with players, the penalty assessment seemed to influence players not to use these systems. In reality, the benefits in most instances would have outweighed the "cost". The results indicated that IVNS was potentially useful under severe congestion or incidents where the perceived benefit clearly outweighs the perceived cost.. In the four penalty assessment cases identified, there was a net increase in score.

The experiment highlighted a perception problem with ATIS technologies. Drivers perceive a "cost" factor for using HAR or IVNS. There is an inherent cost of tuning into HAR instead on one's favorite radio station, and a real out-of-pocket cost for purchasing an in-vehicle navigation unit. FASTCARS players, unable to quantify the potential score improvements with respect to the user penalty, opted not to take advantage of these technologies. In the real-world many drivers perceive costs for purchasing and using these systems but are unable to realize the corresponding benefits. A formal assessment of these costs and benefits is necessary.

FUTURE RESEARCH

There are many experiments that could be performed with FASTCARS. In its existing format, the simulator could be used for other trip types (such as commuter) and to allow players a wider range of pre-trip options including departure time choice and information acquisition. An enhanced graphical display is being considered to improve the map display and the in-vehicle navigation system.

Results from these analyses and other studies will be used as part of the Advanced Traffic Management System Testbed Research Program being conducted in Irvine. Part of this effort is to assess the effectiveness of and traveler response to various advances traveler information systems under a broad range of implementation conditions. The collected data will also be useful in the efforts to develop a real-time simulation capability that can operate on-line to predict dynamic response under an integrated freeway-arterial ATMS/ATIS system. Predicting optimal or equilibrium assignment and effecting optimal real-time feedback control between freeway and arterial systems is dependent on driver behavior and response.

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Figure 1: Layout of Terrapin Traffic Network

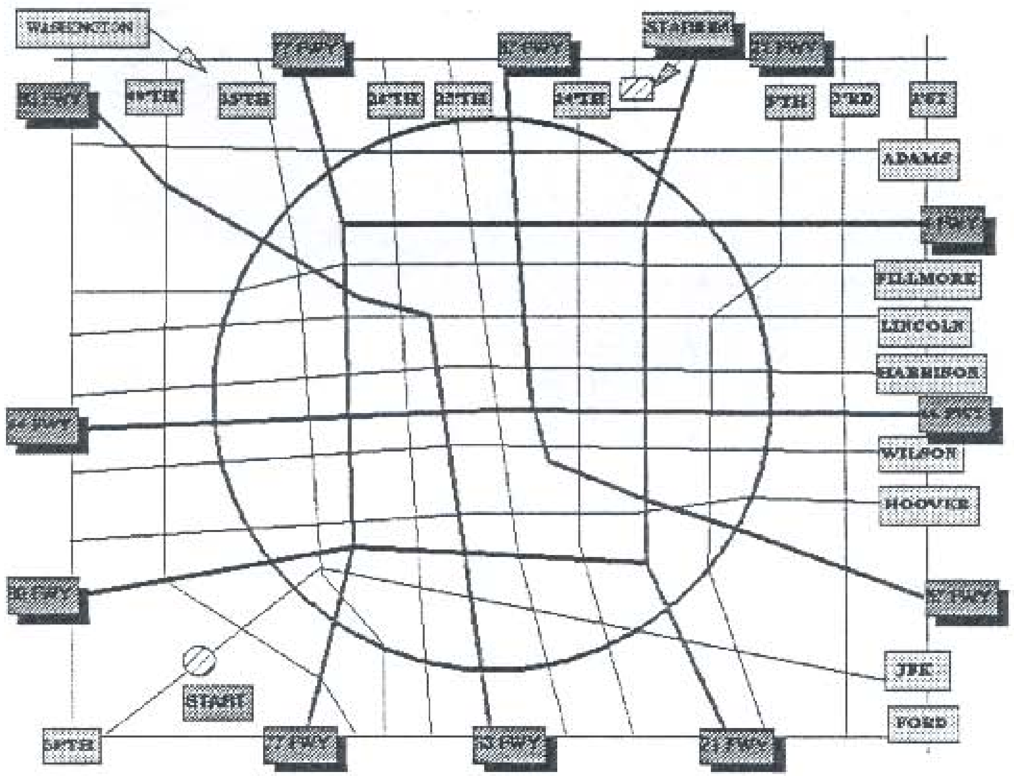


Figure 2: Data Analysis Process

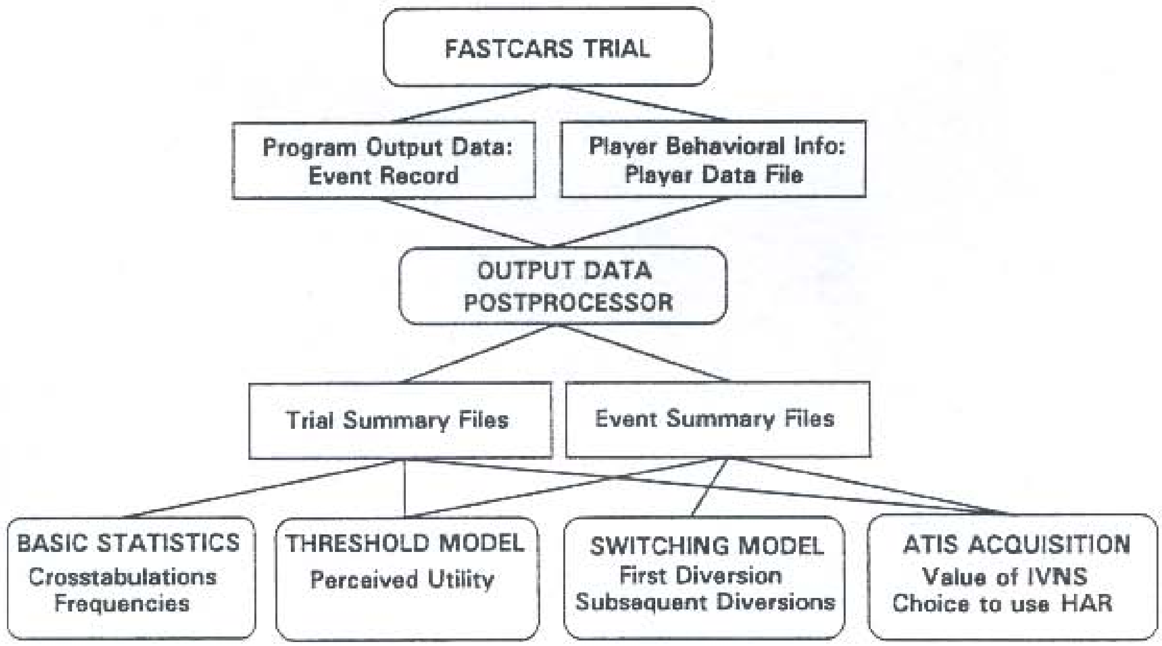
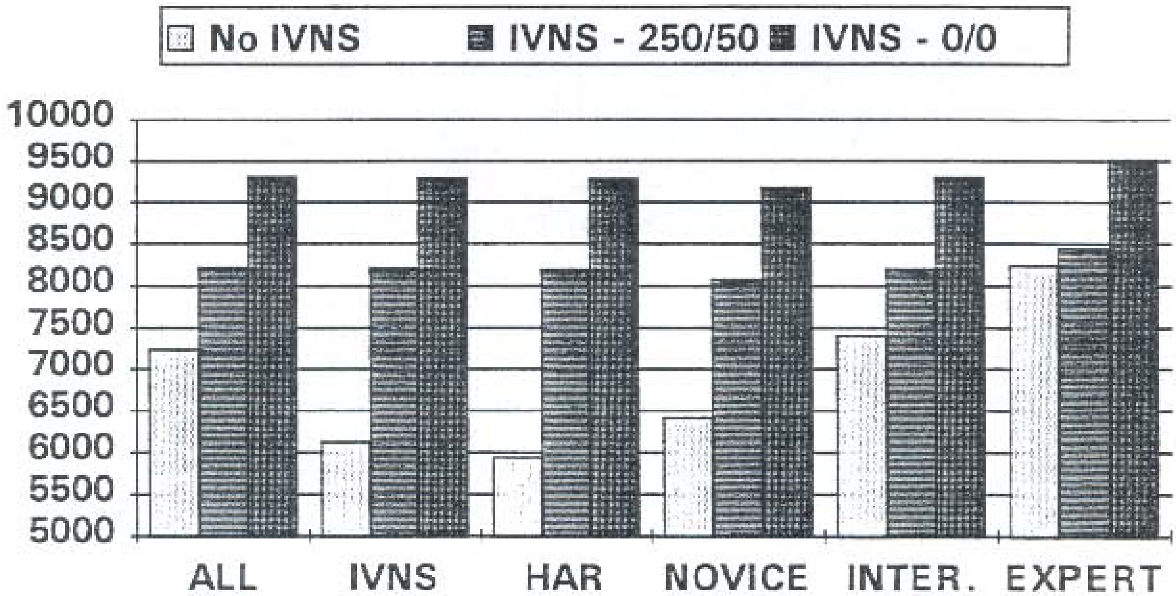


Figure 3: Event level Analysis : Value of IVNS



KEY TO COLUMN HEADERS

ALL	=	All Players
IVNS	=	Players using IVNS During Trip
HAR	=	Players using HAR during Trip
NOVICE	=	Players with Userlevel = 1
INTER	=	Players with Userlevel = 2
EXPERT	=	Players with Userlevel = 3

Table 1: Sample Output Event Records

5 - 22 - 1992	{* date of simulation *}
inputs\baselink.dat	{* link data base *}
inputs\goals.dat	{* goal file used *}
3	{* incident file (1-10) *}
6.30 7.30 2335.74 -108.56	{* starting and departure time *}
1058 103 2497 3 3 9264.60	{*O-D Pair, player, trials, familiarity, score *}
5 5 5 2 5 3	{* behavioral statistics *}
3 5 5 5 1 1 0	{* post-simulation responses *}

{* event records *}

1	0	2	1058	1858	0.00	0.00	0	0	0.00	32.00	0	0	0	80	0	10	10	0	0
5	0	2	1858	45890	3420.32	179.50	2	0	1.09	33.00	0	0	0	80	0	10	10	0	0
5	0	2	45890	1758	3187.40	412.22	4	0	2.90	39.00	0	0	0	80	0	10	10	0	0
5	0	2	1758	5895	3071.98	527.52	5	0	3.69	34.00	0	0	0	80	0	10	0	0	0
3	0	1	5895	9596	2988.70	610.70	6	0	4.29	40.00	0	0	0	80	0	10	10	0	0
5	0	1	9596	5795	2943.66	655.69	6	1	4.97	56.00	0	0	0	80	0	10	10	0	0
5	0	1	5795	5695	2862.68	736.57	6	1	5.66	31.00	0	0	0	80	0	10	10	0	0
4	2	2	5695	5656	2250.88	1347.62	6	1	7.48	10.00	0	0	0	80	0	10	10	0	0

Table 2: Event Data Variables

Variable Name	Coded As	Description
Divert	[0,1]	0 = No Divert, 1 = Diversion
Trials	[Integer]	Number of trials played
Userlvl	[1,2,3]	1=Novice, 2=Intermediate, 3=Expert
Gender	[0,1]	0=Male, 1=Female
Exper	[1-4]	Driving Experience
B1 - B8	[1-5]	8 behavioral questions rated 1(strong disagree) to 5 (strong agree)
Asl	[Real]	Average speed on current link
Ast	[Real]	Average speed for trip
Asp	[Real]	Average speed for current path
Asr	[Real]	Average speed for current road
Rdchg	[Integer]	Number of road changes thus far
Evstop	[Integer]	Stop lights encountered thus far
Onfl	[Integer]	Previous times on from-link
Ontl	[Integer]	Previous times on to-link
Onatl	[Integer]	Previous times on best alternate to-link
Typefl	[0,1]	Road type of from-link (0=freeway, 1=arterial)
Typetl	[0,1]	Road type of to-link
Typeatl	[0,1]	Road type of best alternate to-link
Mfl	[Real]	Userlvl/Map level of from-link
Mtl	[Real]	Userlvl/Map level of to-link
Matl	[Real]	Userlvl/Map level of best alternate-link
Numdiver	[Integer]	Number of diversions thus far
Enddist	[Real]	Shortest path distance to destination
Spdgrad	[Real]	Change in speed from last link
Spdratio	[Real]	Aslink / Link free flow speed
Currroad	[Real]	Distance travelled on current road
HAR	[0,1]	0=OFF, 1=ON
IVNS	[0,1]	0=OFF, 1=ON
VMS	[0-4]	0=no vms, 1 = no congestion, 2=minor congestion, 3=heavy congestion, 4=incident

Table 3: Trial Data Frequencies

(Number of Observations = 108)

FREQUENCY OF SCORES

	< 2500	> 2500	> 5000	>7500	>9000
COUNT	8	12	22	33	33
PERCENT	7.41	11.11	20.37	30.56	30.56

FREQUENCY OF HAR USAGE

	0 HAROFF	1 HARON
COUNT	70	38
PERCENT	64.81	35.19

FREQUENCY OF IVNS USAGE

	0 IVNSOFF	1 IVNSON
COUNT	89	19
PERCENT	82.41	17.59

FREQUENCY OF AT LEAST ONE DIVERSION

	0 DIVERT	>1 DIVERT
COUNT	46	62
PERCENT	42.59	57.41

FREQUENCY OF DIVERSIONS

	0 DIVERT	1 DIVERT	2 DIVERT	3+ DIVERT
COUNT	46	27	13	22
PERCENT	42.59	25.00	12.04	20.37

FREQUENCY OF USERLEVEL

	1 NOVICE	2 INTERMEDIATE	3 EXPERT
COUNT	40	42	26
PERCENT	37.04	38.89	24.07

Table 4: Trial Data Initial Route Choice

FREQUENCY OF INITIAL ROUTES SELECTED

	1	2	3	4	5
COUNT	14	1	12	1	0
PERCENT	12.96	0.93	11.11	0.93	0.00

	6	7	8	9	10
COUNT	16	0.00	39	14	11
PERCENT	14.81	0.00	36.11	12.96	10.19

KEY TO INITIAL ROUTES

1	77-4-21 freeways	6	80-21 Freeways
2	77-4-57 freeways	7	80-21-57 Freeways
3	77-beltway	8	Beltway Clockwise
4	77-66-21 freeways	9	Beltway counterclockwise
5	77-66-57 freeways	10	Other Route

** Please Refer to Figure 1 for map of network

Table 5: Trial Data Descriptive Statistics

(Number of Observations = 108)

VARIABLE	MEAN	STD. DEV.	MINIMUM	MAXIMUM
Score	7242.45	2633.97	-638.45	9860.76
Userlevel	1.87	0.77	1.0	3.0
Diversions	1.35	1.71	0.00	8.00
Trip Time (secs)	2833.09	658.12	1884.20	4815.90
Ave Speed (mph)	37.96	5.17	23.30	50.10
Road Changes	6.41	2.37	2.00	17.00
Trip Distance	29.16	4.19	23.00	44.30
WT 1	46.62	22.12	0.00	100.00
WT 2	22.69	17.06	0.00	60.00
WT 3	10.73	8.89	0.00	40.00
WT 4	12.65	12.03	0.00	40.00
WT 5	7.31	7.72	0.00	30.00
Penalties	373.88	570.19	0.00	2428.30

Table 6: Trial Category Analyses - Userlvl by Divert

Userlvl by Number of Diversions

	0	1	2	3+
1-Novice	13	8	7	12
2-Medium	20	11	4	7
3-Expert	13	8	2	3
TOTALS	46	27	13	22

Chi-Square (6 d.f.) = 7.03
Gamma = -0.272
Somer's d = -0.192
tau-b = -0.187

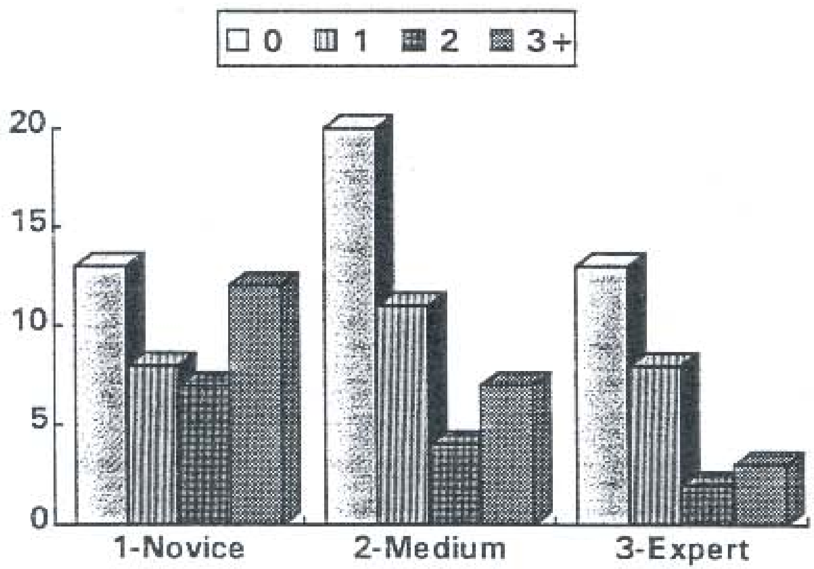


Table 7: Trial Category Analyses - Userlvl by Information

	Userlvl by Har		Userlvl by IVNS	
	0-HarOff	1-HarOn	0-IvnsOff	1-IvnsOn
1-Novice	24	16	31	9
2-Medium	24	18	34	8
3-Expert	22	4	24	2
TOTALS	70	38	99	19

Userlvl by Har	Userlvl by IVNS
Chi-Square (2 d.f.) = 5.96	Chi-Square (2 d.f.) = 2.48
Gamma = -0.289	Gamma = -0.308
Somer's d = -0.133	Somer's d = -0.088
tau-b = -0.159	tau-b = -0.132

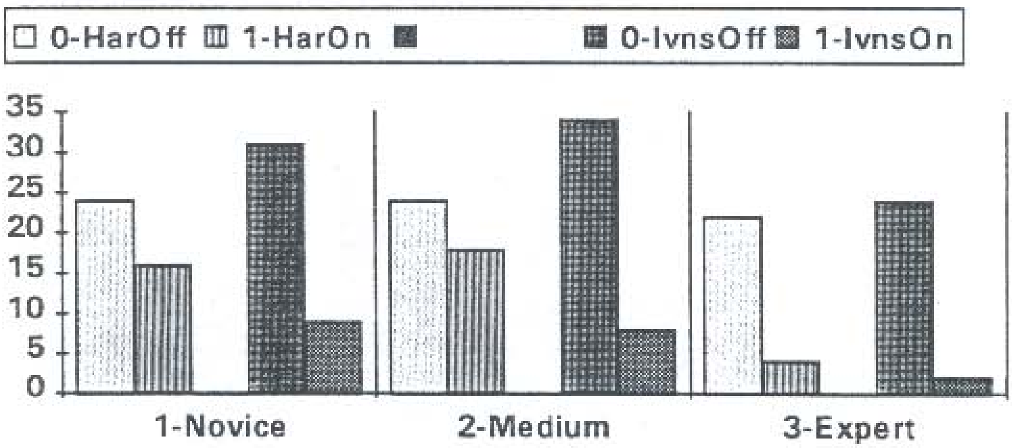


Table 8: Trial Category Analyses - Score by Uservl

	1-Novice	2-Medium	3-Expert
< 2500	4	4	0
> 2500	9	2	1
> 5000	6	10	6
> 7500	17	8	8
> 9000	4	18	11
TOTALS	40	42	26

Chi-Square (8 d.f.) = 23.35
Gamma = 0.351
Somer's d = 0.273
tau-b = 0.254

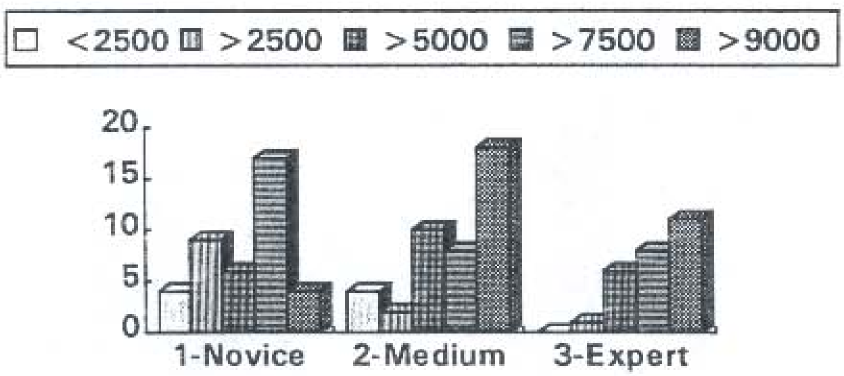


Table 9: Trial Category Analyses - Score by Information

	Score by Har		Score by IVNS	
	0-HarOff	1-HarOn	0-IvnsOff	1-IvnsOn
< 2500	2	6	5	3
> 2500	5	7	9	3
> 5000	13	9	16	6
> 7500	20	13	28	5
> 9000	30	3	31	2
TOTALS	70	38	99	19

Score by Har	Score by IVNS
Chi-Square (4 d.f.) = 18.81	Chi-Square (4 d.f.) = 7.23
Gamma = -0.574	Gamma = -0.459
Somer's d = -0.280	Somer's d = -0.141
tau-b = -0.360	tau-b = -0.228

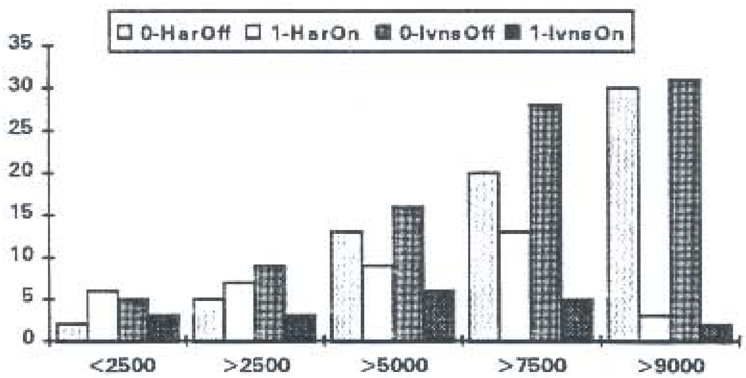


Table 10: Trial Category Analyses - VMS by HAR and IVNS

	Vms by Har		Vms by IVNS	
	0-HarOff	1-HarOn	0-IvnsOff	1-IvnsOn
0 - NoVms	1	1	1	1
1 - Clear	11	6	14	3
2-Minor	9	4	11	2
3-Major	37	12	44	5
4-Incident	12	15	19	8
TOTALS	70	38	99	19

Vms by Har:
Chi-Square (4 d.f.) = 7.67
Gamma = 0.216
Somer's d = 0.103
tau-b = 0.128

Vms by IVNS:
Chi-Square (4 d.f.) = 6.04
Gamma = 0.153
Somer's d = 0.047
tau-b = 0.074

	Har by Ivns	
	0-IvnsOff	1-IvnsOn
0-HarOff	70	0
1-HarOn	19	19
TOTALS	89	19

Chi-Square (1 d.f.) = 42.47
Gamma = 1.00
Somer's d = 0.50
tau-b = 0.627

Table 11: Event Level Analysis: Primary Diversions

************* LOGIT ESTIMATION *************

Dependent variable: divert

Value	Label	Count	Percent
0	NoDivert	67	51.94
1	Divert	62	48.06

Independent Variable	Estimated Coefficient	Standard Error	t-Statistic
one	5.45	1.45	3.76
aslink	-0.0088	0.0024	-3.71
ontl	-1.55	0.49	-3.19
mtl	-3.86	1.043	-3.70
matl	3.49	0.99	3.50
vms	0.50	0.27	1.81
typeatl	-1.57	0.70	-2.23

auxiliary statistics	at convergence	initial
log likelihood	-33.83	-89.42
number of observations	129	
percent correctly predicted	88.372	
Rho Squared	0.6217	

Table 12: Event Level Analysis: Secondary Diversions

********** LOGIT ESTIMATION **********

Dependent variable: divert

Value	Label	Count	Percent
0	NoDivert	77	47.83
1	Divert	84	52.17

Independent Variable	Estimated Coefficient	Standard Error	t-Statistic
one	-1.41	1.41	-1.00
mtl	-2.30	0.81	-2.85
matl	1.80	0.80	2.26
numdiver	1.12	0.25	4.58
enddist	0.16	0.0049	3.37
typetl	4.34	1.02	4.25
typeatl	-3.44	0.99	-3.46
spdratio	-2.30	1.01	-2.28

auxiliary statistics	at convergence	initial
log likelihood	-54.96	-111.59
number of observations	161	
percent correctly predicted	85.714	
Rho Squared	0.5057	